ISOS-14 Field Guide
The Ordovician of Estonia

Edited by Olle Hints and Ursula Toom

14th International Symposium on the Ordovician System, Estonia, July 19-21, 2023
Pre-conference Field Excursion: The Ordovician of Estonia, July 15-18, 2023

ISOS-14 Field Guide: The Ordovician of Estonia

Edited by Olle Hints and Ursula Toom

14th International Symposium on the Ordovician System, Estonia, July 2023

Pre-conference Field Excursion: The Ordovician of Estonia; July 15-18, 2023

The conference and field excursion are supported by:
IGCP Project "'Rocks and the Rise of Ordovician Life"
University of Tartu
Tallinn University of Technology
Geological Survey of Estonia
Estonian Museum of Natural History

Recommended reference to this publication:

Ainsaar, L. 2023. Stop 11: Aru-Lõuna (Kunda-Aru) quarry. In: Hints, O. and Toom, U. (eds). *ISOS-14 Field Guide: The Ordovician of Estonia*. TalTech Department of Geology, Tallinn, p. 65–68.

Electronic copy available at: https://geoloogia.info/reference/47491

Printed by Alfapress OÜ

ISBN 978-9916-80-008-9 (printed)
ISBN 978-9916-80-009-6 (pdf)

Tallinn, 2023

Stop 4: Põõsaspea cliff

Olle Hints

Location: Latitude 59.226065°N, longitude 24.03648°E; Lääne County, NW Estonia.
Stratigraphy: Sandbian, Haljala and Keila regional stages, Kahula Formation and Kinnekulle K-bentonite.
Status: Cliff is under nature protection, no hammering, but loose material may be collected.
More information: https://geoloogia.info/en/locality/12690

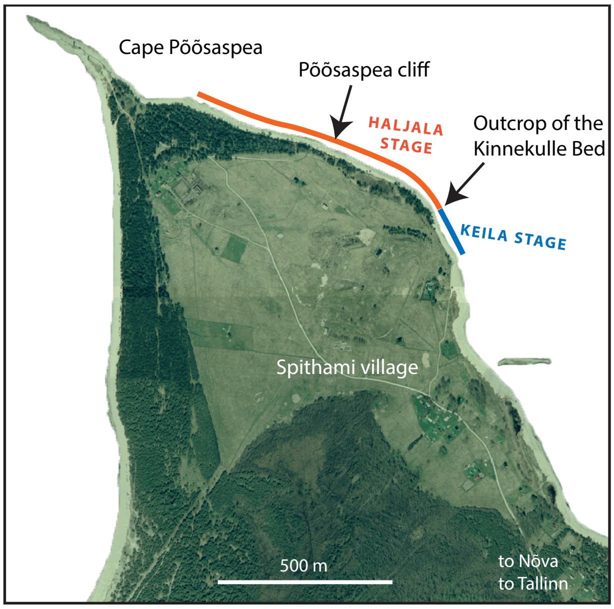

Fig. 4.1. Locality map showing the Põõsaspea cliff with late Sandbian limestone and the outcrop of the Kinnekulle K-bentonite (after Hints et al. 2008).

The bedrock outcrop on the eastern coast of Põõsaspea Cape, in the village of Spithami (historically Spitham or Spithamn), was well known already to Friedrich Schmidt (1881). He described several fossils from the locality and used Spithamn as a reference site in his geological cross-section (Schmidt 1881, p. 58).

According to Rõõmusoks (1970), the low cliff at Põõsaspea Cape exposes ca 1.5 m of variably argillaceous limestones of the Jõhvi Stage (now substage of the Haljala Regional Stage). It was discovered much later that the southern part of the section also hosts the Kinnekulle K-bentonite and limestones of the Keila Regional Stage, in total thickness of more than 1 m (Hints et al. 2008; Perrier et al. 2012; further details below). The Põõsaspea cliff is thus complementary to the Madise section (Stop 3), being slightly younger in the southernmost part.

The Põõsaspea cliff is richly fossiliferous; some examples are shown in Fig. 4.3. Rõõmusoks (1970, Table 13) lists 47 taxa of brachiopods, bryozoans, gastropods, trilobites, echinoderms, conulariids, calcareous algae and graptolites. In addition, cephalopods are common mac-

Fig. 4.2. Overview of the Põõsaspea coastal outcrop. The low cliff is exposing fossiliferous argillaceous limestones of the Kahula Formation, Haljala and Keila regional stages. Photo: Gennadi Baranov, 2023.

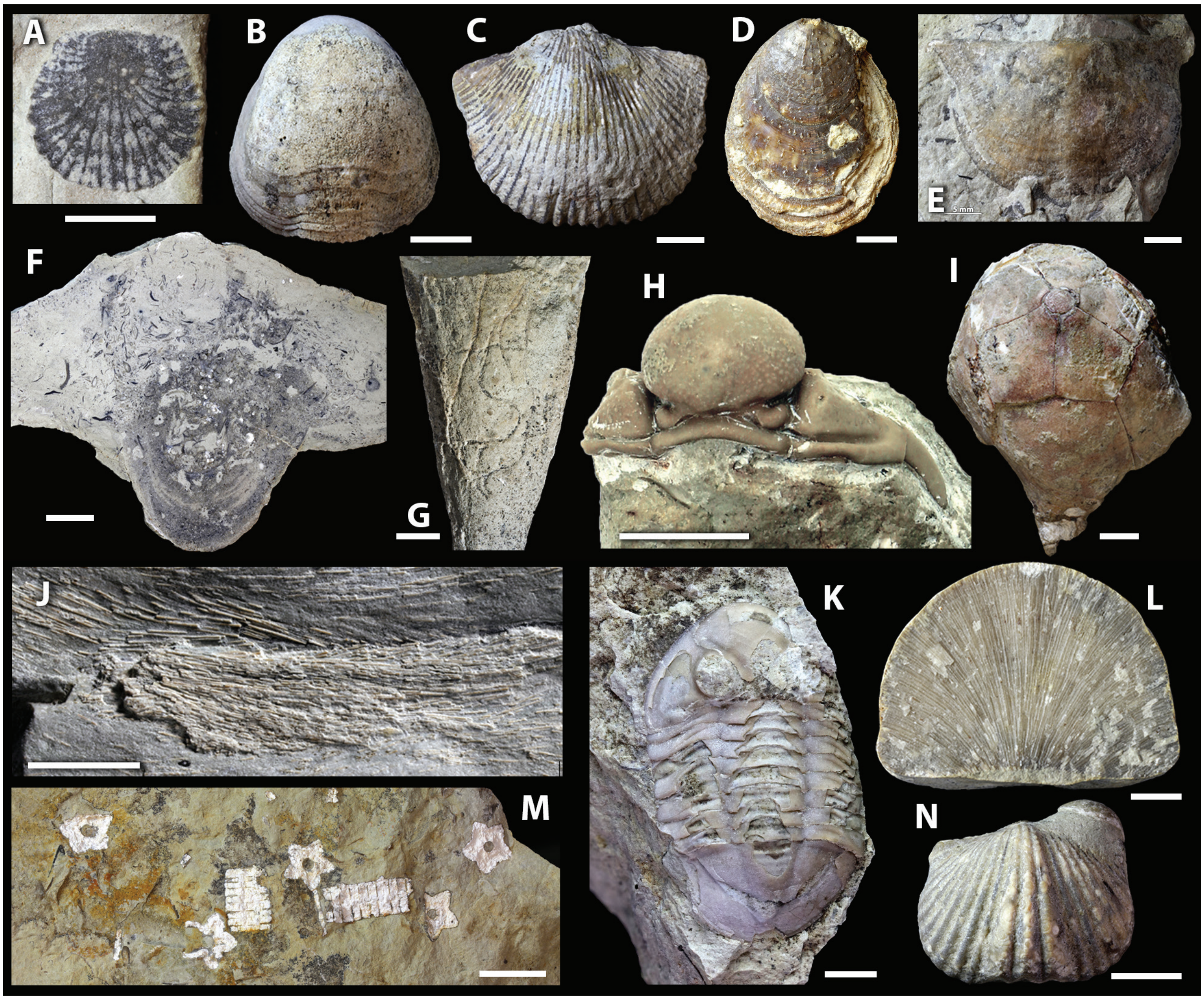

Fig. 4.3. Selected fossils from the Madise scarplet and Põõsaspea outcrop, Haljala and Keila regional stages (Sandbian). Scale bars: B, F, H, J, M – 1 cm; A, C–E; G, I, K, L, N – 5 mm. **A–E** – brachiopods from the Madise scarplet, Haljala Regional Stage; **A** – *Orthisocrania curvicosta*, GIT 772-136; **B** –*Porambonites* (*Equirostra*) *baueri*, GIT 619-553; **C** – *Cyrtonotella kuckersiana frechi*, GIT 400-21; **D** – *Alichovia ramispinosa*, GIT 811-6; **E** – *Clinambon anomalus*, GIT 543-1114. **F–G** – trace fossils from the Madise scarplet, Haljala Regional Stage; **F** – polished vertical section of *Conichnus conicus*, 362-328; **G** – feeding trace *Cochlichnus* on the hyolith steinkern, GIT 696-49-1. **H**, **K** – trilobites from the Madise scarplet, Haljala Regional Stage; **H** – *Hemisphaerocoryphe pseudohemicranium*, TUG 1085-87; **K** – *Asaphus* (*Neoasaphus*) *jewensis*, GIT 453-763. **I** – crinoid *Hoplocrinus estonus* from the Madise scarplet, Haljala Regional Stage, GIT 104-15. **J** – problematic sponge *Pyritonema subulare*, fragment of a root tuft, composed of long needle-like spicules, Põõsaspea, Haljala Regional Stage, GIT 413-82. **L** – bryozoan *Mesotrypa orientalis* from the Põõsaspea Cliff, Haljala Regional Stage, GIT 537-4271. **M** – silicified columnals of echinoderm *Baltocrinus*, Põõsaspea, Haljala Regional Stage, GIT 690-49. **N** – brachiopod *Platystrophia dentata trapezoidalis*, Põõsaspea, Keila Regional Stage, GIT 525-126.

rofossils, but their preservation is usually poor. Recent microfossil studies have identified 71 species of ostracods (Perrier et al. 2012) and 23 species of chitinozoans (Hints et al. 2017) from the upper part of the Põõsaspea succession. Among chitinozoans, the biozonal *Angochitina multiplex* has been identified in a few samples ca 1 m above the Kinnekulle K-bentonite.

The Põõsaspea cliff is one of few places in the eastern Baltic region where the Kinnekulle K-bentonite is exposed (Hints et al. 2008). It is the thickest K-bentonite in the Baltic Ordovician and an excellent time marker for the entire Baltoscandian region (Bergström et al. 1995; Kiipli et al. 2007), serving as the primary criterion for the base of the Keila Regional Stage (Hints et al. 1997, 1999). The bed has been dated radiometrically at 454.9 ± 4.9 Ma in Estonia (Bauert et al. 2014); and using a more precise method in Norway at 454.52 ± 0.50 Ma (Svensen et al. 2015). The thickness of the Kinnekulle K-bentonite decreases eastwards, from more than a metre in southern Scandinavia to a few cm in NW Russia (Fig. 4.7; Bergström et al. 1995).

In the Põõsaspea section, the Kinnekulle Bed is ca 40 cm thick and composed of the following parts (after Hints et al. 2008; starting from the base):

(1) 2–5 cm of dark greyish plastic clay containing hard particles. The basal contact with underlying limestones of the Haljala Regional Stage is sharp.

(2) 2–3 cm of light grey, in places yellow, hard layer of uneven distribution; its topmost part is rich in large biotite phenocrysts.

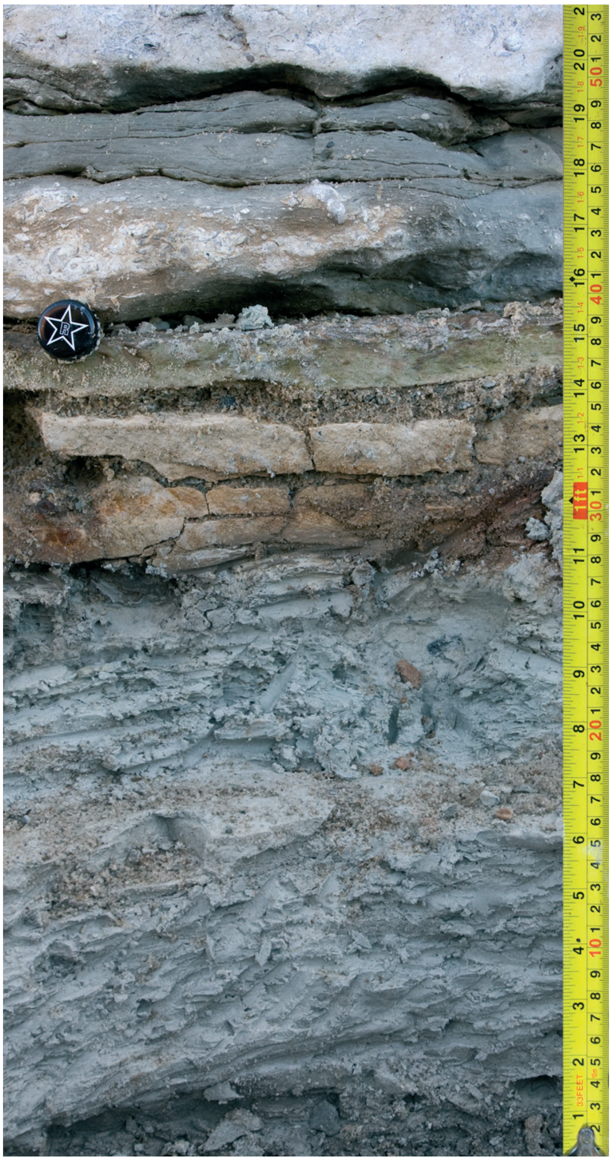

Fig. 4.4. Põõsaspea cliff is one of few localities where the Kinnekulle K-bentonite is exposed in Estonia. Photo: Olle Hints, 2008.

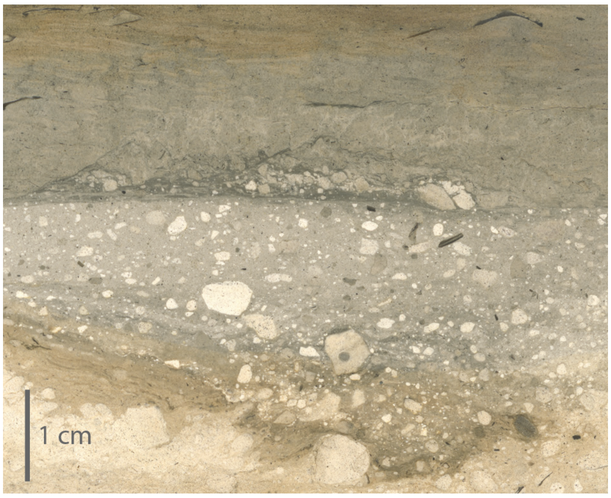

Fig. 4.5. The upper part of the Kinnekulle K-bentonite contains a brecciated layer, indicating early lithification of the volcanic ash. Photo from Hints et al. (2008).

Fig. 4.6. Silicified nodules with calcitic infill are common, alongside with the silicification of fossils. The silica is thought to have derived from the Kinnekulle volcanic ash. Photo: Olle Hints, 2023.

(3) 21–23 cm of light grey (almost white when dry) plastic clay, which embodies irregularly distributed rounded and flattened, almost white nodules of hard variety, up to 10 cm in size. Some nodules display microlamination resulting from varied content of biotite; sometimes, they are bioturbated, burrows are filled with darker material. Angular hard particles are also encountered within the clay.

(4) 5–7 cm of light yellowish to brownish hard feldspathitic layer, occasionally containing elongated or irregularly shaped concretions of pyrite reaching 5 cm in size, bioturbated in places. The top 0.5–3 cm is a distinct breccia with greyish cement containing angular particles from sub-mm to 1 cm in size (Fig. 4.5). The clasts are mostly lighter in colour; no size gradation can be observed. The lower contact of the breccia is irregular, whilst the upper surface is mostly flat and more distinct.

(5) few cm of darker brownish and slightly carbonaceous rock, with abundant brachiopod shells and fragments in the upper part. This is overlain by 10–14 cm of greyish-brown to dark brown kerogenous mudstone containing accumulations of shelly faunas in the lower part and microlaminated kerogenous rock in the upper part. In this interval, the material from volcanic ash is mixed with carbonates and organic matter, and thus the upper boundary of the K-bentonite bed cannot be identified precisely.

The mineral composition of the Kinnekulle Bed at Põõsaspea is dominated by authigenic K-feldspar and illite-smectite (Fig. 4.8; Perrier et al. 2012).

It has been shown that the Kinnekulle volcanic ash-fall had a strong influence on marine biotas (Hints et al. 2003). Even though the extinction of only a few species among ostracods is known (e.g., *Tetrada memorabilis*), both benthic and planktonic communities were stressed and got significantly reorganised after the ash-fall (Perrier et al. 2012; Hints et al. 2017).

Põõsaspea Cape is also famous for a particular type of erratic boulders that are eroded from the uplifted and brecciated basement rocks of the nearby Neugrund meteorite crater (Suuroja and Suuroja 2010). These boulders can be observed on the coast.

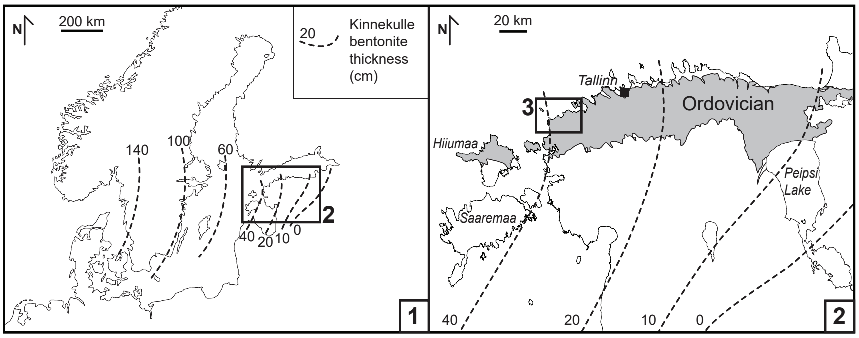

Fig. 4.7. Thickness of the Kinnekulle K-bentonite in Baltoscandia and Estonia (after Perrier et al. 2012).

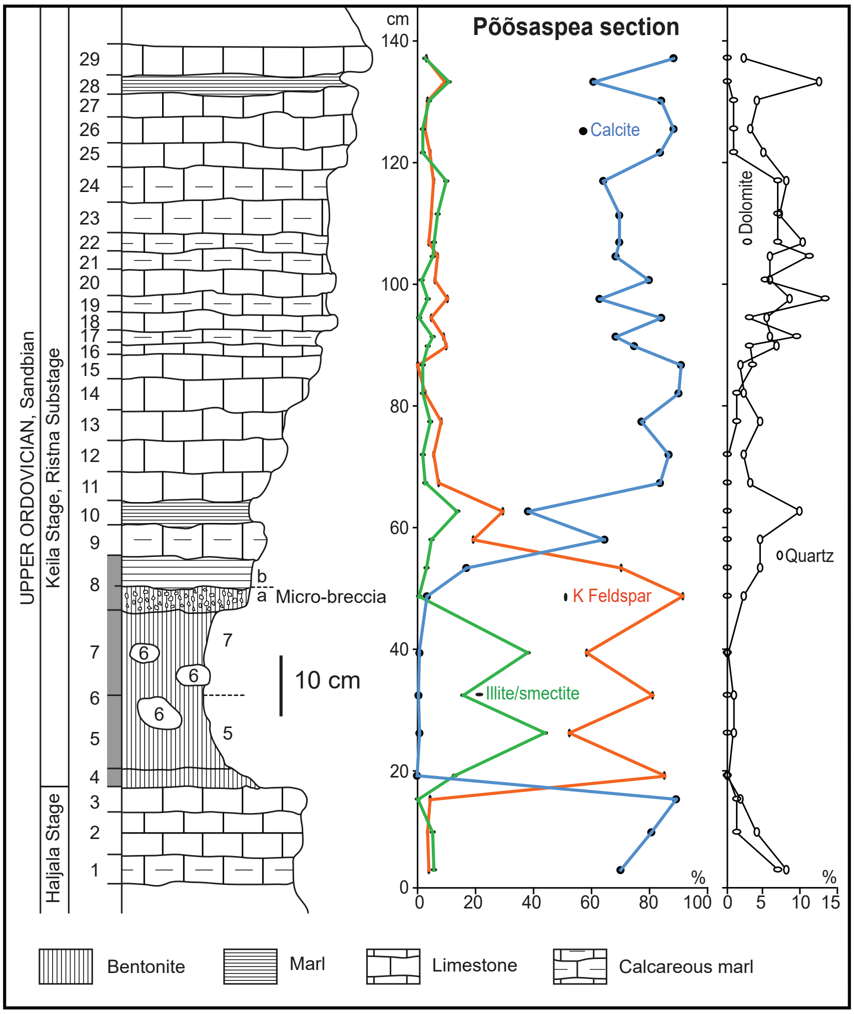

Fig. 4.8. Mineralogical composition of the Kinnekulle K-bentonite and adjacent limestones in the Põõsaspea section (after Perrier et al. 2012).

References

Bauert, H., Isozaki, Y., Holmer, L. E., Aoki, K., Sakata, S. and Hirata, T. 2014. New U–Pb zircon ages of the Sandbian (Upper Ordovician) Big K-bentonite in Baltoscandia (Estonia and Sweden) by LA-ICPMS. GFF, 136, 30–33.

Bergström, S. M., Huff, W. D., Kolata, D. R. and Bauert, H. 1995. Nomenclature, stratigraphy, chemical fingerprinting and areal distribution of some Middle Ordovician K–bentonites in Baltoscandia. GFF, 117, 1–13.

Hints, L., Männik, P., Hints, O. and Hints, R. 2008. Discovery of the Ordovician Kinnekulle K-bentonite at the Põõsaspea cliff, NW Estonia. Estonian Journal of Earth Sciences, 57, 192–196.

Hints, O. and Nõlvak, J. 1999. Proposal for the lower boundary-stratotype of the Keila Regional Stage (Upper Ordovician). Proceedings of the Estonian Academy of Sciences. Geology, 48, 158–169.

Hints, O., Bauert, G., Grigorjeva, I., Nõlvak, J., Meidla, T. and Perrier, V. 2017. Chitinozoan response to a gigantic Late Ordovician volcanic ash fall recorded in northern Estonia. In (Żylińska, A., ed). University of Warsaw, Warszawa, 34–35.

Hints, O., Hints, L., Meidla, T. and Sohar, K. 2003. Biotic effects of the Ordovician Kinnekulle ashfall recorded in northern Estonia. Bulletin of the Geological Society of Denmark, 50, 115–123.

Hints, O., Kallaste, T. and Kiipli, T. 1997. Mineralogy and micropalaeontology of the Kinnekulle altered volcanic ash bed (Ordovician) at Pääsküla, North Estonia. Proceedings of the Estonian Academy of Sciences. Geology, 46, 107–118.

Kiipli, T., Kiipli, E., Kallaste, T., Hints, R., Somelar, P. and Kirsimäe, K. 2007. Altered volcanic ash as an indicator of marine environment, reflecting pH and sedimentation rate – example from the Ordovician Kinnekulle bed of Baltoscandia. Clays and Clay Minerals, 55, 177–188.

Perrier, V., Meidla, T., Tinn, O. and Ainsaar, L. 2012. Biotic response to explosive volcanism: Ostracod recovery after Ordovician ash-falls. Palaeogeography, Palaeoclimatology, Palaeoecology, 365, 166–183.

Rõõmusoks, A. 1970. Stratigraphy of the Viruan Series (Middle Ordovician) in Northern Estonia, I. Valgus Publishers, Tallinn.

Schmidt, Fr. 1881. Revision der ostbaltischen silurischen Trilobiten nebst geognostischer Übersicht des ostbaltischen Silurgebiets. Abt. I. Phacopiden, Cheiruriden und Encrinuriden. Mémoires de l´Académie Impériale des Sciences de St.-Petersbourg, 30, 1–237.

Suuroja, K. and Suuroja, S. 2010. The Neugrund meteorite crater on the seafloor of the Gulf of Finland, Estonia. Baltica, 23, 47–58.

Svensen, H. H., Hammer, Ø. and Corfu, F. 2015. Astronomically forced cyclicity in the Upper Ordovician and U–Pb ages of interlayered tephra, Oslo Region, Norway. Palaeogeography, Palaeoclimatology, Palaeoecology, 418, 150–159.